

UK Patent Application GB 2 196 166 A

(43) Application published 20 Apr 1988

(21) Application No 8721348

(22) Date of filing 10 Sep 1987

(30) Priority data

(31) 8623490

(32) 30 Sep 1986

(33) GB

(51) INT CL
G09F 9/00 G02B 27/22

(52) Domestic classification (Edition J):
G5C A333 A342 A361 A363 HX
U1S 2206 G5C

(56) Documents cited

GB A 2170033 GB A 2129994 WO 81/01201
GB A 2161639 GB 1273062
GB A 2138615 GB 1220705

(58) Field of search

G5C
G2J
Selected US specifications from IPC sub-classes G02B
G09F G09G

(71) Applicants

Martin Lawrence Bass,
25 Clydeway, Rise Park, Romford, Essex RM1 4UR.

Peter Michael Rutherford,
9 Sumatra Road, London NW6 1PS

(72) Inventors

Martin Lawrence Bass
Peter Michael Rutherford

(74) Agent and/or Address for Service

Marks & Clerk,
57-60 Lincoln's Inn Fields, London WC2A 3LS

(54) Display means for stereoscopic images

(57) A stereoscopic display comprises;

a) a plurality of discrete and independently controllable light sources 4 arranged on a surface 6, and,
b) one or more light modifying elements 3 disposed in fixed relation to the surface 6 so as to enable the formation of a moving stereoscopic display which can be viewed by the naked eye. Adjacent light sources 4a, 4b are spaced apart such that the respective images are also spaced apart by the distance between the eyes of a human observer and a stereoscopic display formed by two different images is perceived. The light sources may be formed by interlaced images generated simultaneously or alternately. The light sources 4a, 4b may be constituted by switchable elements such as liquid crystal, LED, gas plasma or phosphor coated regions. A colour display may be provided by suitable formation of the light sources. Instead of the lenticular screen 3 shown, a multi-slot mask or a photographic equivalent may be used. Applications include a television receiver, advertising, leisure industries and education.

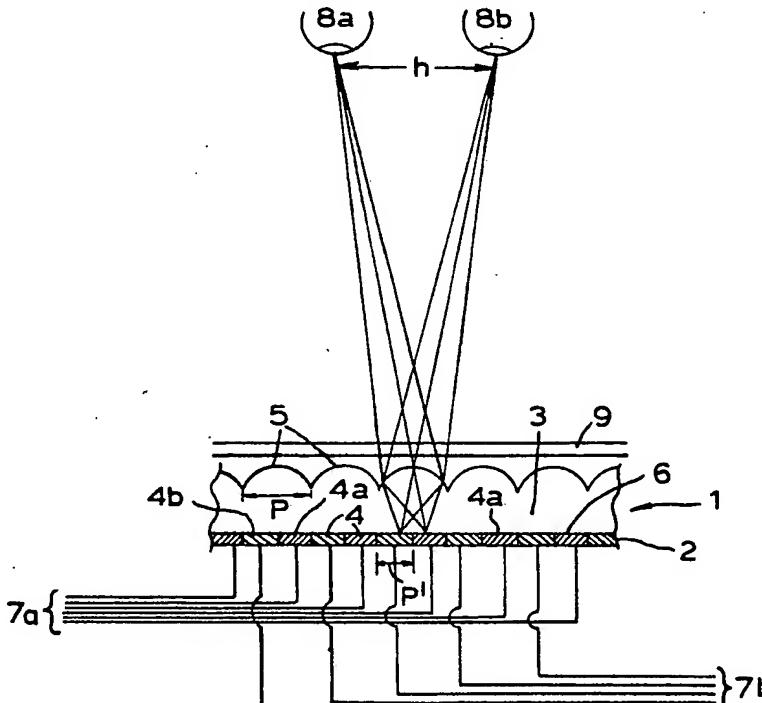


FIG. 1.

GB 2 196 166 A

2196166

1/5

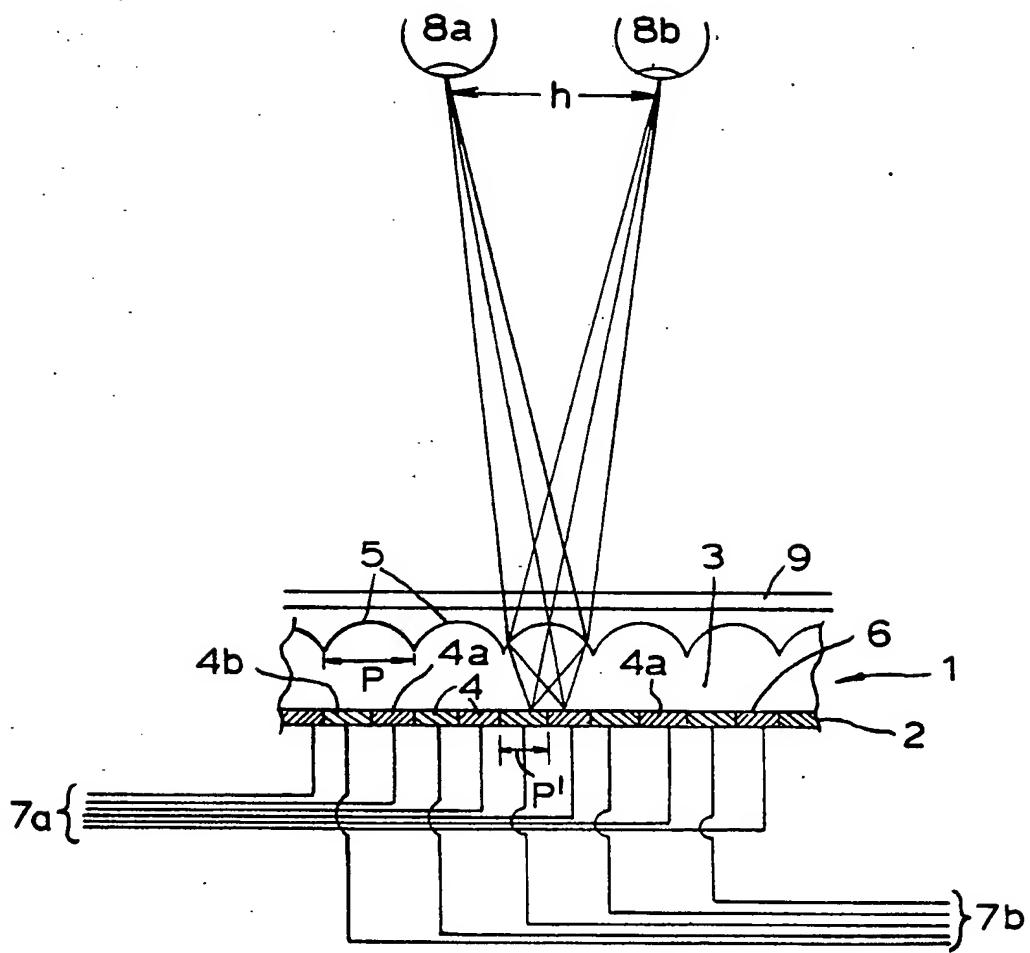


FIG. 1

2/5

2196166

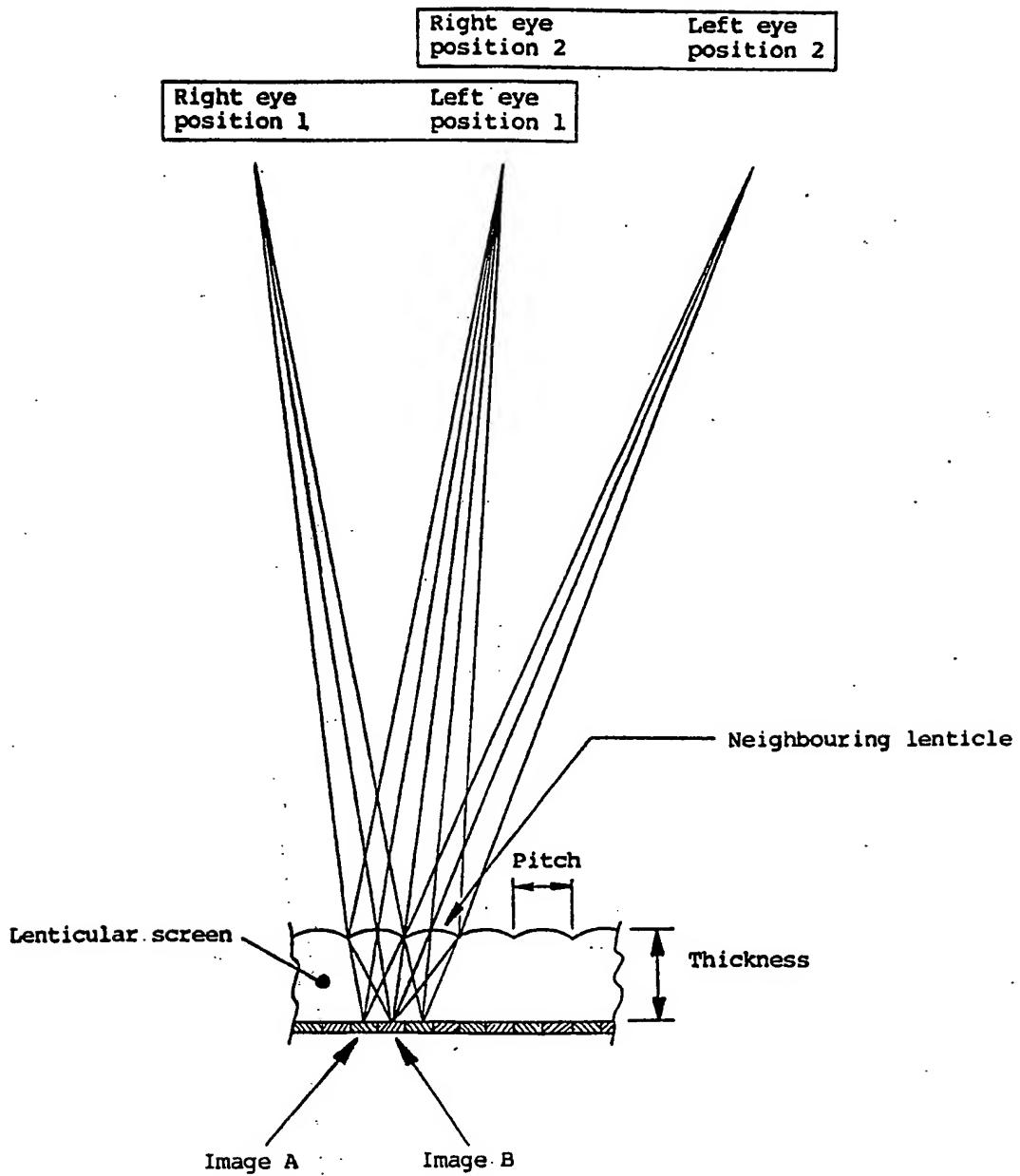


FIGURE 2

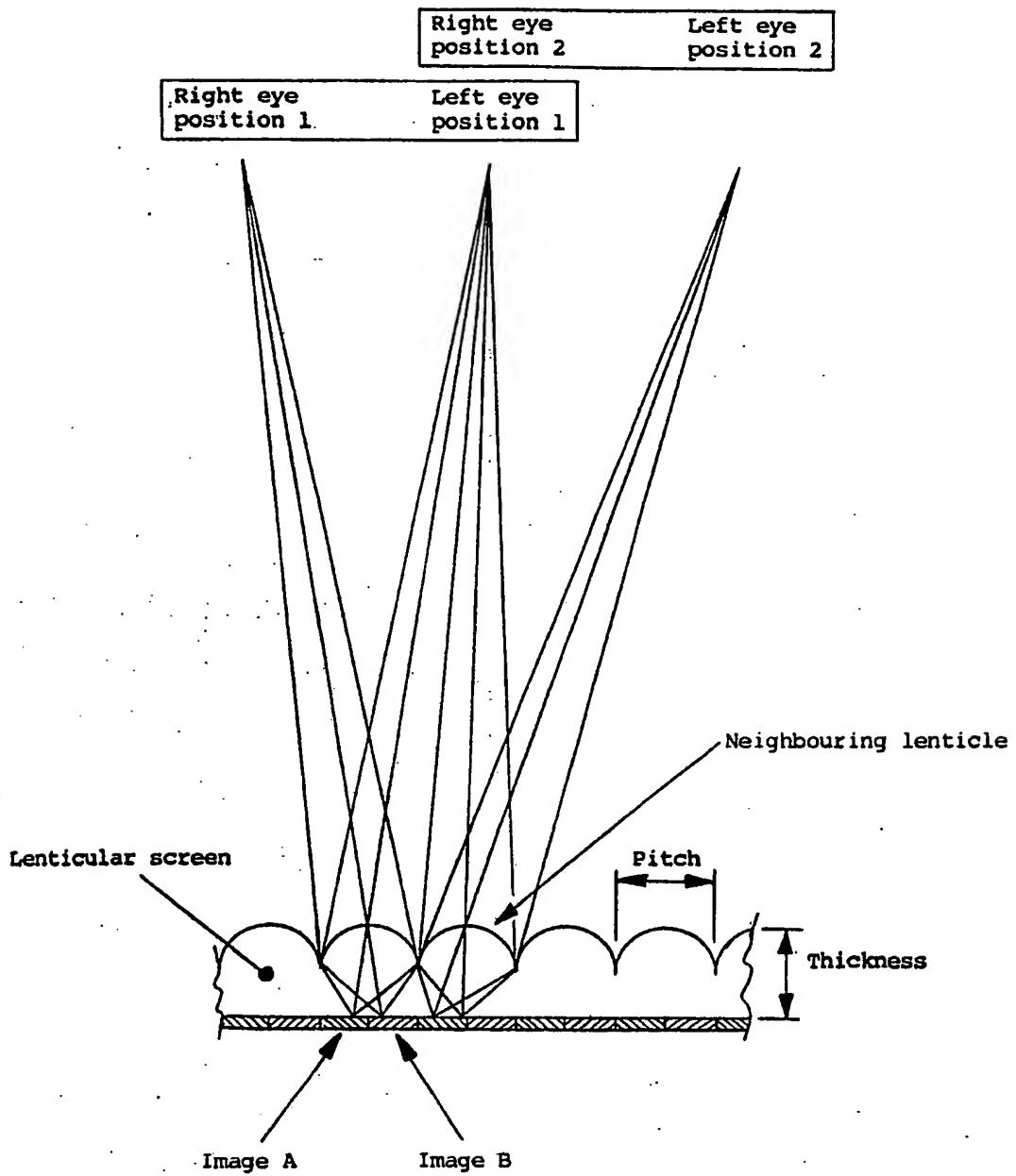


FIGURE 3

4/5

2196166

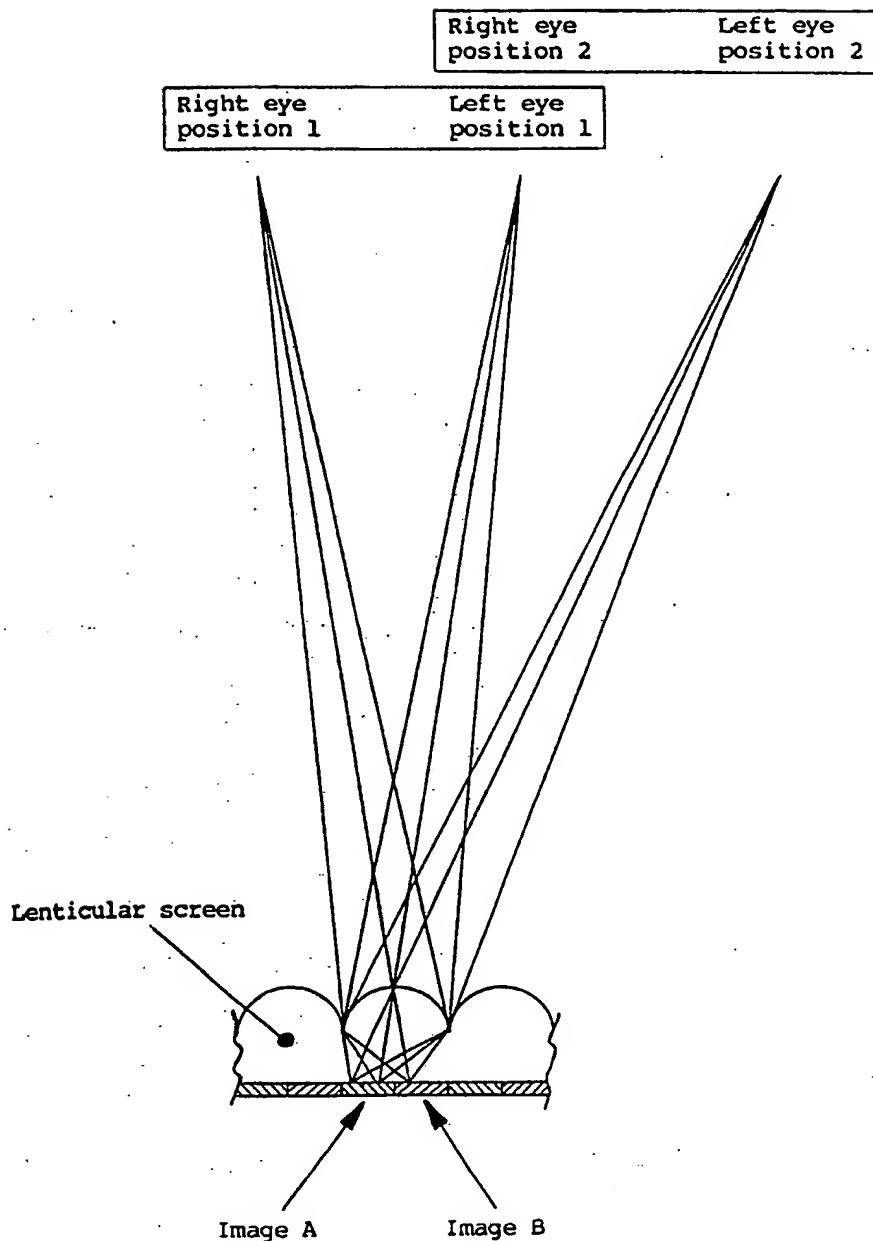


FIGURE 4

5/5

2196166

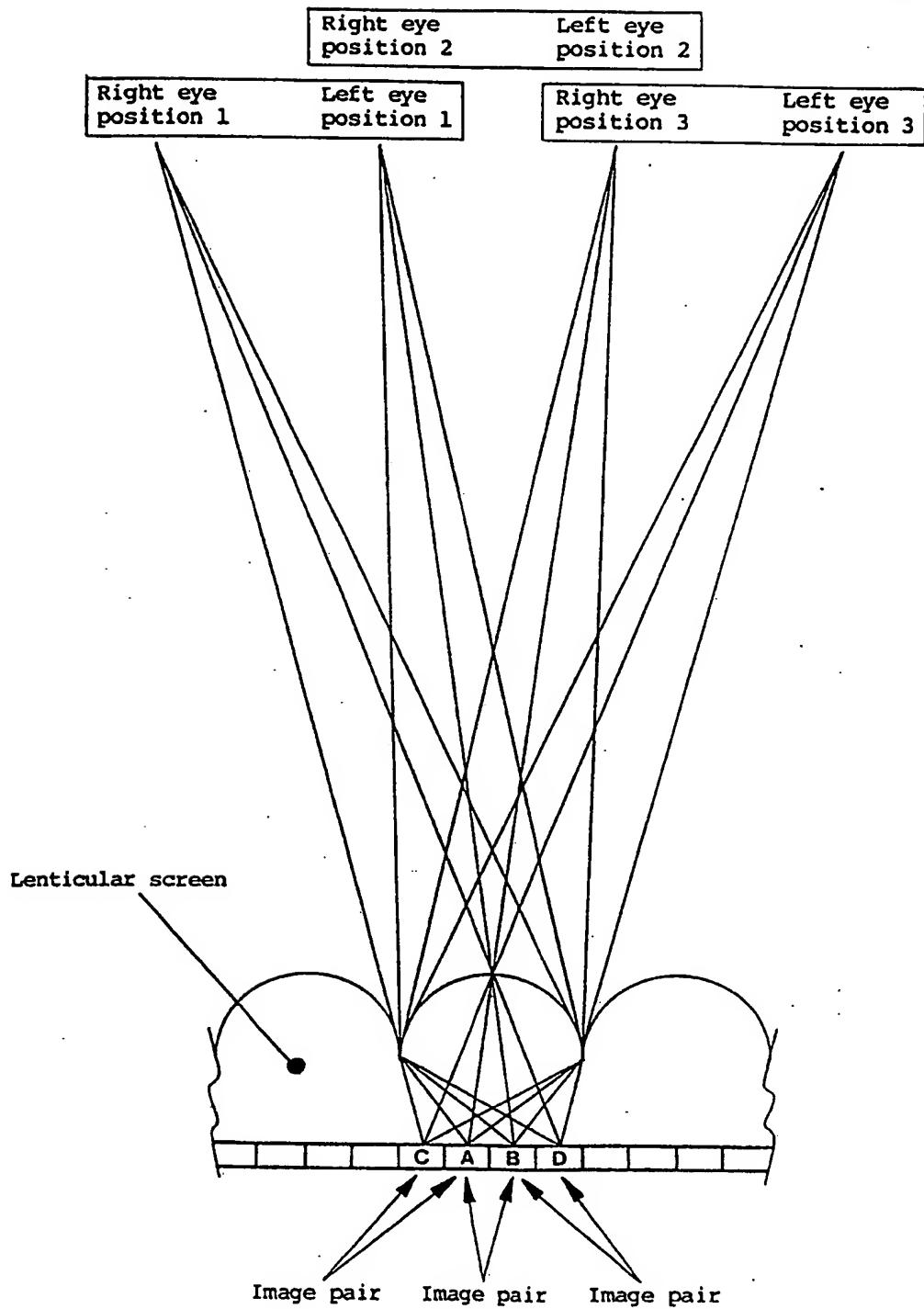


FIGURE 5

SPECIFICATION

Display means for stereoscopic images

5 The present invention relates to stereoscopic display means which enable the formation of at least a pair of images having parallax therebetween.

It is known to produce an illusion of depth 10 or of parallax by providing an observer with a pair of separate images taken from points of view a short distance apart and arranging for each image to be viewed from one eye only.

Stereoscopic display means have previously 15 employed simple blinker like shields and/or binocular eyepieces together with paired photographs or display screens to achieve this object.

As an alternative to separate images, overlaid images have been displayed on a single 20 screen. With "anaglyph" systems these images have differing colours and may be separated by suitably coloured filters worn over the eyes. Analogous systems have employed 25 polarising filters worn over the eyes.

In a further alternative, a pair of alternating 30 images are displayed on a single screen and the eyes of an observer are alternately occluded in phase with the images, enabling image separation to be achieved.

Holograms and parallax panoramagrams are also known to provide an illusion of static 35 three-dimensionality.

With the exception of holograms and panoramagrams, all of the above systems enable the stereoscopic display of moving images, but require the observer to wear some form of optical assembly such as blinkers, lenses, polarising filters or coloured filters over the 40 eyes. While holograms and panoramagrams do not require the use of such optical assemblies they are generally unsuitable for the display of moving images.

It is an object of the present invention to 45 provide stereoscopic display means which can conveniently provide a moveable image and which can be viewed by the naked eye.

According to the present invention there is 50 provided a stereoscopic display means comprising;

a) a plurality of discrete and independently controllable light sources arranged on a surface and,

b) one or more light modifying elements disposed in fixed relation to the surface so as to enable the formation of a three dimensional image.

By arranging the light sources so as to produce at least a pair of movable interlaced images, and employing one or more light modifying elements fixed relative to the surface to separate the pair of interlaced images into a pair of spaced apart images, it is possible to produce a moving stereoscopic display which 65 can be viewed by the naked eye.

Typically, the light sources comprise illuminated liquid crystal elements, visible light emitting diodes, gas plasma elements or discrete phosphor-coated regions of the surface.

70 Other alternatives are possible.

Preferably, the light sources are hard wired by suitable conductors to a switching unit and power supply.

The light modifying elements are preferably 75 provided by a light-transmissive lenticular screen having a plurality of cylindrical lenses disposed in a parallel configuration and having a common focal length. It is also possible to use a screen comprising fly's eye lenses, a screen comprising glass rods and screens comprising glass balls. The individual lenses, rods or balls are referred to as "lenticles" hereafter.

More preferably, one set of light sources is 80 disposed in the focal plane of each lenticle. Each set comprises at least two light sources. The light sources of each set are spaced apart such that the respective images are also spaced apart. Most preferably, the lenticles 85 are of the cylindrical or rod form and each set of light sources comprise a pair, the members of each pair being spaced apart transverse of the longitudinal axis of the lenticle. In use, one light source of the pair displays a picture element which belongs to one of the interlaced 90 images while the other light source of the pair displays a picture element which belongs to the other interlaced image.

Any number of light sources per set may be 95 disposed in the focal plane of each lenticle, to provide a panoramic view which varies as the position of the observer varies. Each set should however consist of at least two light sources.

105 As an alternative to lenticles it is envisaged that a multi-slot mask or a photographic equivalent may constitute an effective light modifying element.

The interlaced images may be generated in 110 several ways. For example, each image may be generated independently and sequentially or both images may be generated simultaneously. In an embodiment of the invention picture elements or pixels of each of the interlaced images are alternately generated. The images 115 may be derived from a pair of spaced apart cameras or generated by a computational device.

In order that the present invention may be 120 further set forth it will be described by way of example only and with reference to the accompanying drawings, in which:-

Figure 1 is a horizontal section through a display means according to the present invention,

Figure 2 illustrates a lenticular screen with a relatively small pitch in relation to the depth of the screen,

Figure 3 illustrates a lenticular screen with a 130 relatively large pitch in relation to the depth of

the screen.

Figure 4 illustrates the conditions under which a non-stereoscopic image will result, and

5 Figure 5 illustrates a display apparatus in which four light sources are located beneath each lenticle.

Referring to Figure 1 there is shown a section through a display means (1) comprising 10 an array of light sources (2) and a lenticular screen (3). Both the array of light sources and the lenticular screen extend into and out of the plane of the paper.

The array of light sources (2) is composed 15 of individual elements (4), each of which is individually connected by conductors (7a, 7b) to a switching unit and power supply which are not shown in the Figure. For the purposes of the present example the light sources (4a, 20 4b) are considered as being liquid-crystal devices arranged in a two-dimensional array as known in so-called "flat-screen televisions".

The lenticular screen (3) is composed of 25 parallel cylindrical lens elements or lenticles (5). The lenticles each have a curved outer surface, and a flat inner surface (6) which supports the array of light sources (2). The outer surface of each lenticle has a constant radius of curvature. The transverse extent (p') of 30 each of the light sources (4) is equal to half the lenticular pitch (P). A transparent protective screen (9) may be located in front of the lenticular screen (3).

The light sources (4) are divided into two 35 groups (4a) and (4b). At least one member from each group is located below each lenticle (5) as indicated in the figure by the alternating slope of the cross-hatching on the light sources (4a, 4b). The extent of the light 40 sources in the longitudinal direction of the lenticles is preferably of the order of (p') but may be greater or lesser than (p') depending on the actual design of the light sources.

In Figure 1, the two groups of light sources 45 (4a) and (4b) are wired separately to the switching unit and power supply along respective groups of conductors (7a) and (7b). Considering for the moment only elements (4a) and respective conductors (7a), a composite 50 image made up of individual picture elements may be displayed on the surface (6) when the light sources (4a) are active. The alternate group of light sources (4b) together with the respective conductors (7b) enable the display 55 of a second image interlaced with the first on the same surface (6).

It is particularly preferred that the long axes 60 of the lenticles or the equivalent axes of any alternative light-modifying elements are arranged to lie in a vertical direction when viewed, that is in a direction perpendicular to a line joining the pupils of the observer. Moreover, the order in which the image presented by any one group of light sources (say 4a) is 65 updated is preferably one which is ordered

along rather than across the longitudinal axes of the lenticles (5).

When the surface (6) is viewed at a distance through the lenticular screen (3) the separation of the two interlaced images brought about by the lenticles (5) approximates to the spacing (h) between the pupils of the human eye. Consequently, the eyes (8a, 8b) of an observer perceive different images, the image 70 formed by the light sources (4a) being seen by one eye (8a) and the image formed by the light sources (4b) being seen by the other eye (8b). As the images form a pair which differ only in the supposed viewpoint of the observer, the illusion of parallax and 3-dimensional 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 1230 1235 1240 1245 1250 1255 1260 1265 1270 1275 1280 1285 1290 1295 1300 1305 1310 1315 1320 1325 1330 1335 1340 1345 1350 1355 1360 1365 1370 1375 1380 1385 1390 1395 1400 1405 1410 1415 1420 1425 1430 1435 1440 1445 1450 1455 1460 1465 1470 1475 1480 1485 1490 1495 1500 1505 1510 1515 1520 1525 1530 1535 1540 1545 1550 1555 1560 1565 1570 1575 1580 1585 1590 1595 1600 1605 1610 1615 1620 1625 1630 1635 1640 1645 1650 1655 1660 1665 1670 1675 1680 1685 1690 1695 1700 1705 1710 1715 1720 1725 1730 1735 1740 1745 1750 1755 1760 1765 1770 1775 1780 1785 1790 1795 1800 1805 1810 1815 1820 1825 1830 1835 1840 1845 1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095 2100 2105 2110 2115 2120 2125 2130 2135 2140 2145 2150 2155 2160 2165 2170 2175 2180 2185 2190 2195 2200 2205 2210 2215 2220 2225 2230 2235 2240 2245 2250 2255 2260 2265 2270 2275 2280 2285 2290 2295 2300 2305 2310 2315 2320 2325 2330 2335 2340 2345 2350 2355 2360 2365 2370 2375 2380 2385 2390 2395 2400 2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480 2485 2490 2495 2500 2505 2510 2515 2520 2525 2530 2535 2540 2545 2550 2555 2560 2565 2570 2575 2580 2585 2590 2595 2600 2605 2610 2615 2620 2625 2630 2635 2640 2645 2650 2655 2660 2665 2670 2675 2680 2685 2690 2695 2700 2705 2710 2715 2720 2725 2730 2735 2740 2745 2750 2755 2760 2765 2770 2775 2780 2785 2790 2795 2800 2805 2810 2815 2820 2825 2830 2835 2840 2845 2850 2855 2860 2865 2870 2875 2880 2885 2890 2895 2900 2905 2910 2915 2920 2925 2930 2935 2940 2945 2950 2955 2960 2965 2970 2975 2980 2985 2990 2995 3000 3005 3010 3015 3020 3025 3030 3035 3040 3045 3050 3055 3060 3065 3070 3075 3080 3085 3090 3095 3100 3105 3110 3115 3120 3125 3130 3135 3140 3145 3150 3155 3160 3165 3170 3175 3180 3185 3190 3195 3200 3205 3210 3215 3220 3225 3230 3235 3240 3245 3250 3255 3260 3265 3270 3275 3280 3285 3290 3295 3300 3305 3310 3315 3320 3325 3330 3335 3340 3345 3350 3355 3360 3365 3370 3375 3380 3385 3390 3395 3400 3405 3410 3415 3420 3425 3430 3435 3440 3445 3450 3455 3460 3465 3470 3475 3480 3485 3490 3495 3500 3505 3510 3515 3520 3525 3530 3535 3540 3545 3550 3555 3560 3565 3570 3575 3580 3585 3590 3595 3600 3605 3610 3615 3620 3625 3630 3635 3640 3645 3650 3655 3660 3665 3670 3675 3680 3685 3690 3695 3700 3705 3710 3715 3720 3725 3730 3735 3740 3745 3750 3755 3760 3765 3770 3775 3780 3785 3790 3795 3800 3805 3810 3815 3820 3825 3830 3835 3840 3845 3850 3855 3860 3865 3870 3875 3880 3885 3890 3895 3900 3905 3910 3915 3920 3925 3930 3935 3940 3945 3950 3955 3960 3965 3970 3975 3980 3985 3990 3995 4000 4005 4010 4015 4020 4025 4030 4035 4040 4045 4050 4055 4060 4065 4070 4075 4080 4085 4090 4095 4100 4105 4110 4115 4120 4125 4130 4135 4140 4145 4150 4155 4160 4165 4170 4175 4180 4185 4190 4195 4200 4205 4210 4215 4220 4225 4230 4235 4240 4245 4250 4255 4260 4265 4270 4275 4280 4285 4290 4295 4300 4305 4310 4315 4320 4325 4330 4335 4340 4345 4350 4355 4360 4365 4370 4375 4380 4385 4390 4395 4400 4405 4410 4415 4420 4425 4430 4435 4440 4445 4450 4455 4460 4465 4470 4475 4480 4485 4490 4495 4500 4505 4510 4515 4520 4525 4530 4535 4540 4545 4550 4555 4560 4565 4570 4575 4580 4585 4590 4595 4600 4605 4610 4615 4620 4625 4630 4635 4640 4645 4650 4655 4660 4665 4670 4675 4680 4685 4690 4695 4700 4705 4710 4715 4720 4725 4730 4735 4740 4745 4750 4755 4760 4765 4770 4775 4780 4785 4790 4795 4800 4805 4810 4815 4820 4825 4830 4835 4840 4845 4850 4855 4860 4865 4870 4875 4880 4885 4890 4895 4900 4905 4910 4915 4920 4925 4930 4935 4940 4945 4950 4955 4960 4965 4970 4975 4980 4985 4990 4995 5000 5005 5010 5015 5020 5025 5030 5035 5040 5045 5050 5055 5060 5065 5070 5075 5080 5085 5090 5095 5100 5105 5110 5115 5120 5125 5130 5135 5140 5145 5150 5155 5160 5165 5170 5175 5180 5185 5190 5195 5200 5205 5210 5215 5220 5225 5230 5235 5240 5245 5250 5255 5260 5265 5270 5275 5280 5285 5290 5295 5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700 5705 5710 5715 5720 5725 5730 5735 5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800 5805 5810 5815 5820 5825 5830 5835 5840 5845 5850 5855 5860 5865 5870 5875 5880 5885 5890 5895 5900 5905 5910 5915 5920 5925 5930 5935 5940 5945 5950 5955 5960 5965 5970 5975 5980 5985 5990 5995 6000 6005 6010 6015 6020 6025 6030 6035 6040 6045 6050 6055 6060 6065 6070 6075 6080 6085 6090 6095 6100 6105 6110 6115 6120 6125 6130 6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6190 6195 6200 6205 6210 6215 6220 6225 6230 6235 6240 6245 6250 6255 6260 6265 6270 6275 6280 6285 6290 6295 6300 6305 6310 6315 6320 6325 6330 6335 6340 6345 6350 6355 6360 6365 6370 6375 6380 6385 6390 6395 6400 6405 6410 6415 6420 6425 6430 6435 6440 6445 6450 6455 6460 6465 6470 6475 6480 6485 6490 6495 6500 6505 6510 6515 6520 6525 6530 6535 6540 6545 6550 6555 6560 6565 6570 6575 6580 6585 6590 6595 6600 6605 6610 6615 6620 6625 6630 6635 6640 6645 6650 6655 6660 6665 6670 6675 6680 6685 6690 6695 6700 6705 6710 6715 6720 6725 6730 6735 6740 6745 6750 6755 6760 6765 6770 6775 6780 6785 6790 6795 6800 6805 6810 6815 6820 6825 6830 6835 6840 6845 6850 6855 6860 6865 6870 6875 6880 6885 6890 6895 6900 6905 6910 6915 6920 6925 6930 6935 6940 6945 6950 6955 6960 6965 6970 6975 6980 6985 6990 6995 7000 7005 7010 7015 7020 7025 7030 7035 7040 7045 7050 7055 7060 7065 7070 7075 7080 7085 7090 7095 7100 7105 7110 7115 7120 7125 7130 7135 7140 7145 7150 7155 7160 7165 7170 7175 7180 7185 7190 7195 7200 7205 7210 7215 7220 7225 7230 7235 7240 7245 7250 7255 7260 7265 7270 7275 7280 7285 7290 7295 7300 7305 7310 7315 7320 7325 7330 7335 7340 7345 7350 7355 7360 7365 7370 7375 7380 7385 7390 7395 7400 7405 7410 7415 7420 7425 7430 7435 7440 7445 7450 7455 7460 7465 7470 7475 7480 7485 7490 7495 7500 7505 7510 7515 7520 7525 7530 7535 7540 7545 7550 7555 7560 7565 7570 7575 7580 7585 7590 7595 7600 7605 7610 7615 7620 7625 7630 7635 7640 7645 7650 7655 7660 7665 7670 7675 7680 7685 7690 7695 7700 7705 7710 7715 7720 7725 7730 7735 7740 7745 7750 7755 7760 7765 7770 7775 7780 7785 7790 7795 7800 7805 7810 7815 7820 7825 7830 7835 7840 7845 7850 7855 7860 7865 7870 7875 7880 7885 7890 7895 7900 7905 7910 7915 7920 7925 7930 7935 7940 7945 7950 7955 7960 7965 7970 7975 7980 7985 7990 7995 8000 8005 8010 8015 8020 8025 8030 8035 8040 8045 8050 8055 8060 8065 8070 8075 8080 8085 8090 8095 8100 8105 8110 8115 8120 8125 8130 8135 8140 8145 8150 8155 8160 8165 8170 8175 8180 8185 8190 8195 8200 8205 8210 8215 8220 8225 8230 8235 8240 8245 8250 8255 8260 8265 8270 8275 8280 8285 8290 8295 8300 8305 8310 8315 8320 8325 8330 8335 8340 8345 8350 8355 8360 8365 8370 8375 8380 8385 8390 8395 8400 8405 8410 8415 8420 8425 8430 8435 8440 8445 8450 8455 8460 8465 8470 8475 8480 8485 8490 8495 8500 8505 8510 8515 8520 8525 8530 8535 8540 8545 8550 8555 8560 8565 8570 8575 8580 8585 8590 8595 8600 8605 8610 8615 8620 8625 8630 8635 8640 8645 8650 8655 8660 8665 8670 8675 8680 8685 8690 8695 8700 8705 8710 8715 8720 8725 8730 8735 8740 8745 8750 8755 8760 8765 8770 8775 8780 8785 8790 8795 8800 8805 8810 8815 8820 8825 8830 8835 8840 8845 8850 8855 8860 8865 8870 8875 8880 8885 8890 8895 8900 8905 8910 8915 8920 8925 8930 8935 8940 8945 8950 8955 8960 8965 8970 8975 8980 8985 8990 8995 9000 9005 9010 9015 9020 9025 9030 9035 9040 9045 9050 9055 9060 9065 9070 9075 9080 9085 9090 9095 9100 9105 9110 9115 9120 9125 9130 9135 9140 9145 9150 9155 9160 9165 9170 9175 9180 9185 9190 9195 9200 9205 9210 9215 9220 9225 9230 9235 9240 9245 9250 9255 9260 9265 9270 9275 9280 9285 9290 9295 9300 9305 9310 9315 9320 9325 9330 9335 9340 9345 9350 9355 9360 9365 9370 9375 9380 9385 9390 9395 9400 9405 9410 9415 9420 9425 9430 9435 9440 9445 9450 9455 9460 9465 9470 9475 9480 9485 9490 9495 9500 9505 9510 9515 9520 9525 9530 9535 9540 9545 9550 9555 9560 9565 9570 9575 9580 9585 9590 9595 9600 9605 9610 9615 9620 9625 9630 9635 9640 9645 9650 9655 9660 9665 9670 9675 9680 9685 9690 9695 9700 9705 9710 9715 9720 9725 9730 9735 9740 9745 9750 9755 9760 9765 9770 9775 9780 9785 9790 9795 9800 9805 9810 9815 9820 9825 9830 9835 9840 9845 9850 9855 9860 9865 9870 9875 9880 9885 9890 9895 9900 9905 9910 9915 9920 9925 9930 9935 9940 9945 9950 9955 9960 9965 9970 9975 9980 9985 9990 9995 9999

The known monochrome design of CRT has a continuous phosphor-coating on its screen, in contrast to discrete regions of phosphor. Known colour CRTs use a shadow mask to define pixels on the screen. Nominally, the shadow mask defines the spot size of the pixels on the screen, but in practice the spread of the electron beam usually exceeds the dot pitch of the shadow mask. Thus, conventionally the spot sized pixels have ill defined edges whereas for use in the present invention well defined discrete pixels are required.

Even if it were possible to incorporate the lenticular screen into the screen of the CRT, maintaining precise registration between the lenticles and the pixels would be exceedingly difficult, due to the high degree of accuracy that would be required from the electron beam deflection circuitry. It is also highly desirable in the present invention to ensure a very high degree of picture stability in the horizontal direction. CRTs do not have good picture stability, the width and height of the picture changes by a small amount as the picture brightness alters, therefore the width of picture is hardly ever stable. Also CRTs and associated circuitry do not have a high picture stability over a large temperature range. It is, of course, known to provide discrete groups of phosphor dots on the screen of certain forms of colour television receiver. But, the problem of registration with the lenticles of a separate lenticular screen remains. The above problems indicate the difficulty in applying the present invention to CRT type arrangements.

Cathode Ray Tubes rely upon electrons to activate the phosphor. A screen of discrete phosphor-coated regions for use in the present invention could be activated by a laser.

With the use of a lenticular screen, the applicants have discovered that the viewing angle changes with the depth-to-pitch ratio of the screen. The depth and pitch dimensions are illustrated in Figure 2. In Figure 2 the pitch is relatively small with respect to the depth of the screen. Figure 2 illustrates the effect of the relatively small pitch as an observer moves from a central position, position 1, to a slightly off-centre position, position 2. In the off-centre position the observer views with his left eye through a neighbouring lenticle and observes the incorrect image (image "B") under the original lenticle, and views image "A" through the neighbouring lenticle with his right eye. This effect in which a wrong image is viewed by one eye is referred to as the pseudoscopic effect.

The angle between the lines along which the left and right eyes observe the images increases as the viewing distance is reduced. Thus, it is desirable to increase the viewing angle of the display if it is to be used with a reduced viewing distance. The applicants have discovered that the angle at which the pseu-

doscopic effect occurs can be made larger by increasing the pitch of the lenticles with respect to their depth. This increases the viewing angle of the screen, as shown in Figure 3.

70 Figure 3, also emphasises the increase in pixel size with pitch. That is, the registration between light sources and lenticles is to be retained regardless of variations in pitch of the lenticles. Thus increasing the pitch of the lenticles provides a greater viewing angle without moving from one pixel to the next.

As well as indicating the increase of viewing angle with pitch, Figure 3 also illustrates the intermediate stage between a stereoscopic display and onset of the pseudoscopic effect. In Figure 3, at position 2, the right eye views through the neighbouring lenticle image "A", while the left eye views the same image "A" through a neighbouring lenticle. But, because of the relatively large pitch of the lenticles the left eye views a "correct" image (image "A"), that is a neighbouring pixel from the overall picture. Thus, both eyes view image "A" which results in a two dimensional image being viewed. This can also be seen in figure 4, where the same effect arises under different conditions. In position 2 of Figure 4, the left and right eyes of the observer both view a single light source through the same lenticle.

95 A non-stereoscopic image results.

The present invention provides a technique for increasing the three dimensional viewing angle of the display. This resides in increasing the number of light sources located beneath each lenticle. The arrangement of Figure 1 is based upon a set of light sources per lenticle, per row across the display, consisting of two light sources. This is the minimum configuration. It is possible for each set to consist of more than two light sources and an arrangement having four light sources per set is shown in Figure 5. An uneven number of light sources per set can also be used. In each case, one pair of light sources is viewed by an observer in a first position and another pair of sources is viewed as the observer effectively moves through a small distance to a second position. One light source will be common to both pairs of light sources.

110 115 Figure 5 illustrates the use of a set of four light sources per lenticle. This provides three image pairs per lenticle. With the optimum depth-to-pitch ratio, increasing the number of light sources per set to four can increase the three dimensional viewing angle three-fold. This panoramic effect is indicated in Figure 5 by the three viewing positions which are shown.

The display device depicted in figure 5 and 125 one method of controlling the light sources thereof will now be described. It is to be understood that the following description represents the applicants current understanding of the invention and the validity of the appended claims is not to be determined by any state-

ments of theory contained herein.

Figure 5 shows three lenticles each having a respective set of four light sources in registration therewith. The light sources are annotated

5 A, B, C and D for the central one of the illustrated lenticles. Lines representing an observer's line of light, from three different positions, are also shown for this central lens. It is believed that the lens has the effect of masking all but one member of the set of light sources for each eye. In the central viewing position, position 2, the observer's left eye views light source A and the observer's right eye views light source B. Thus, A and B provide the image pair for the central viewing position. If the observer's viewing position moves slightly off centre, to position 1 the observer's left eye views light source B and the observer's right eye views light source D. The image pair for position 1 is thus, B and D. Similarly, if the observer's viewing position moves slightly off centre in the opposite direction, to position 3, the observer's left eye views light source C and the observer's right eye views light source A. The image pair for position 3 is thus, A and C. Hence, four light sources per set provide three image pairs and an increased viewing angle can be provided.

30 To establish a three dimensional panoramic effect the image must appear to an observer to move across the screen as the observer's viewing position moves transversely with respect to the screen. A method of determining which light sources should be activated to achieve this effect will now be described. It is believed that this method is effective because of certain physiological reactions of the human brain. In particular, it is believed that the human brain tends to sum separate neighbouring images as viewed by the left and right eyes. This summation is believed to exist at a single level, that is having summed two neighbouring pixels, each seen only by a respective eye of the observer; the resultant is not further summed with any other such resultants.

45 In figure 5 consider the light sources under the left hand lens to be designated C1, A1, B1 and D1, respectively, from the left hand extreme. Similarly, consider the light sources under the right hand lens to be designated C3, A3, B3 and D3 respectively, from the left hand extreme of that lens. Also, consider the central light sources as being A2, B2, C2, D2—rather than just the A, B, C, D as illustrated.

50 From position 2, the observer will "see" a single "dot" if light sources A1 and B2 are activated. This "dot" will appear to be at the boundary between the left and central lenses, at a distance corresponding to the lens pitch in front of the light source array. If light source D3 is also activated, the effect of the observer moving to position 1 will be that the "dot" appears to move to the boundary

between the central and right lenses, again at a distance corresponding to the lens pitch in front of the light source array. That is, as the observer moves to the right, the "dot" appears to move to the left.

70 In position 2, the observer's brain appears to sum images A1 and B2 and in position 1 the observer's brain appears to sum images B2 and D3. These image pairs (A1, B2 and B2, D3) are in accordance with the image pairs (A, B and B, D) explained above with reference to the lines of sight shown in figure 5. One member of each pair (A1, D3) is from a neighbouring set because the resultant is required to be one pitch length in front of the light source array. In position 2 with only light sources A1 and B3 activated, the observer would "see" a "dot" in front of the central lens at a distance corresponding to twice the lenticular pitch from the light source array.

75 It will be apparent from the above that the number of lenses involved in the production of a single "dot" depends on the desired position of the "dot" with respect to the plane of the array. Assuming that correct viewing from each of positions 1, 2 and 3 is required: if the "dot" is to be in the plane of the array, all four light sources associated with one lens must be activated; if the "dot" is to be one pitch length displaced from the array, a different light source from each of four neighbouring lens sets must be activated (e.g. the image pairs for position 1, 2, 3 are D4B3, B3A2 and A2C1, respectively from four neighbouring lenses). It is to be noted that displacement of a "dot" behind the array is obtained just as readily as displacement in front of the array. (That is, the image pairs for positions 1, 2 and 3 become D1B2, B2A3 and A3C4 respectively).

80 90 Thus, if one knows where each "dot" of the final three dimensional picture is required, the light sources which need to be activated to produce each "dot" can be determined.

95 100 110 120 125 130 This task can readily be achieved by a suitably programmed conventional computer. The input to the computer may, for example, be the images in digital form from two cameras viewing the same object from slightly different positions. Hence, the display device of the present invention can be used in a television receiver where the received broadcast signal is in the form of several digital images. (One digital image should be provided for each light source per set. That is, in the four pixel arrangement, four separate digital images should preferably be provided. These images could be different views as seen by a single camera or could be provided by respective cameras.) Subsequent processing of the broadcast signals occurs in the television receiver. The broadcasting of a digital television image (a single or "one camera" view of a scene) has already been successfully achieved. Alternatively, of course, the fully processed data

could be transmitted, for example, on a cable distribution type network.

Applications of the present invention include its use in advertising, in leisure industries and 5 in education.

CLAIMS

1. A stereoscopic display means comprising:
 - 10 a) a plurality of discrete and independently controllable light sources arranged on a surface, and,
b) one or more light modifying elements disposed in fixed relation to the surface so as to enable the formation of a three dimensional image.
 - 15 2. Display means as claimed in claim 1, wherein the plurality of light sources are adapted and arranged for the display of a pair of interlaced images and the said three dimensional image comprises a pair of spaced apart images having parallax therebetween.
 - 20 3. Display means as claimed in any of the preceding claims wherein the light modifying elements include a light-transmissive lenticular screen comprising a plurality of cylindrical lenses disposed in a parallel configuration.
 - 25 4. Display means as claimed in claim 3, wherein the light sources are arranged in sets with a respective set of light sources being disposed in the focal plane of each cylindrical lens, each set comprising at least two light sources.
 - 30 5. Display means as claimed in claim 4, wherein each set comprises four light sources.
 - 35 6. Display means as claimed in claim 4 or 5, wherein each set of light sources is in registration with a single cylindrical lens.
 - 40 7. Display means as claimed in claim 6, wherein the transverse extent of each set is greater than the pitch of the cylindrical lens.
 - 45 8. Display means as claimed in any preceding claim, wherein the light sources comprise illuminated liquid crystal elements.
 - 50 9. Display means as claimed in any of claims 1 to 7, wherein the light sources comprise visible light emitting diodes.
 - 55 10. Display means as claimed in any of claims 1 to 7, wherein the light sources comprise gas plasma elements.
 - 60 11. Display means as claimed in any of claims 1 to 7, wherein the light sources comprise phosphor-coated regions of the surface.
 12. Display means as claimed in any of claims 1 to 10, wherein the light sources are hard wired by suitable conductors to a switching unit and power supply.
 13. Display means substantially as hereinbefore described by way of example and with reference to the accompanying drawings.